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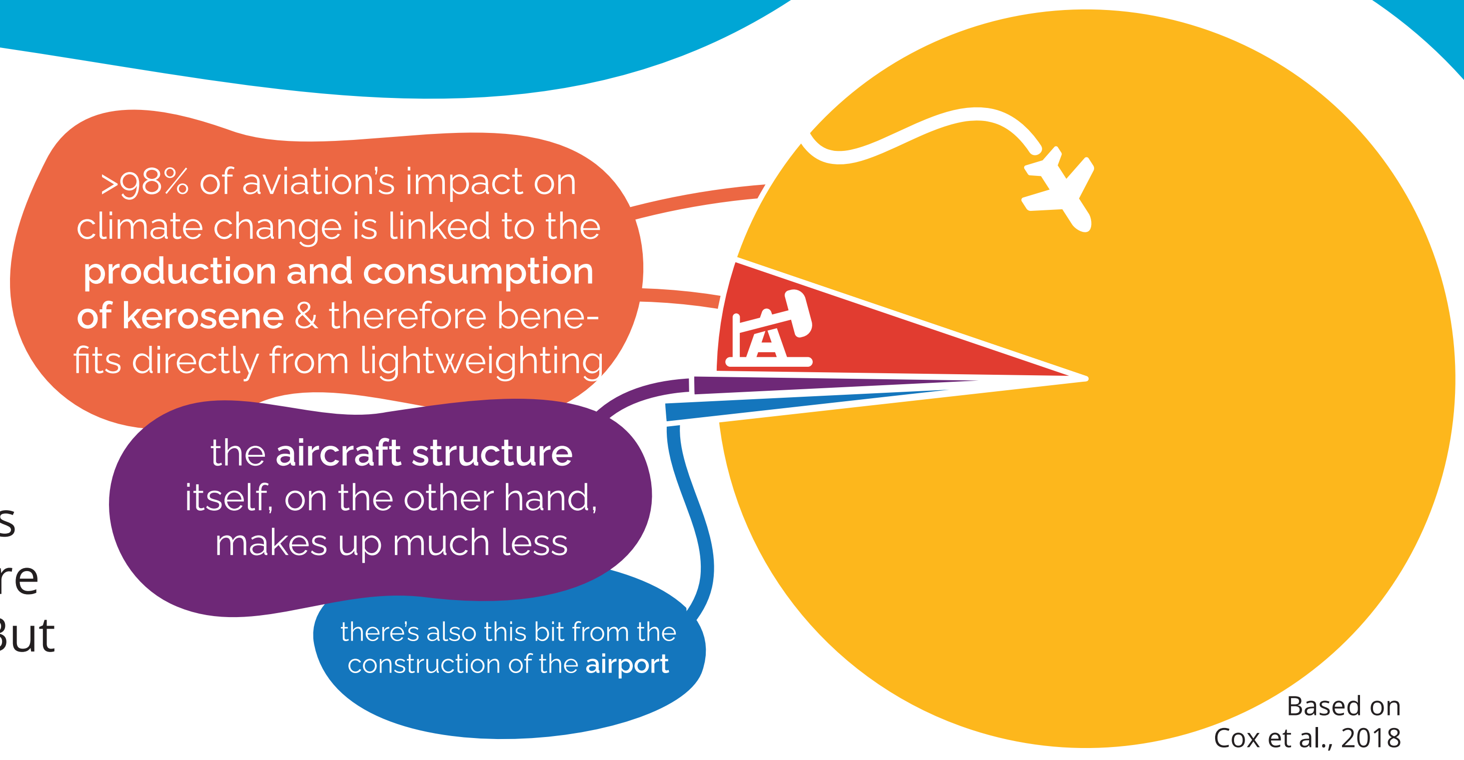
What it means when *"every kilogram counts"*: the relevance of **mass-induced emissions** for a **circular** commercial aviation sector

knowledge gaps & methodology

Problem statement

The benefits for lightweighting of aircraft structures are abundantly clear. However, with materials such as high-performance alloys and polymer composites comes increased cradle-to-gate impacts and unappealing end-of-life solutions.

Strategies to increase circularity potential such as modular design and the use of recycled materials are unapealing if they result in an increase to aircraft mass. But does that always have to be the case?

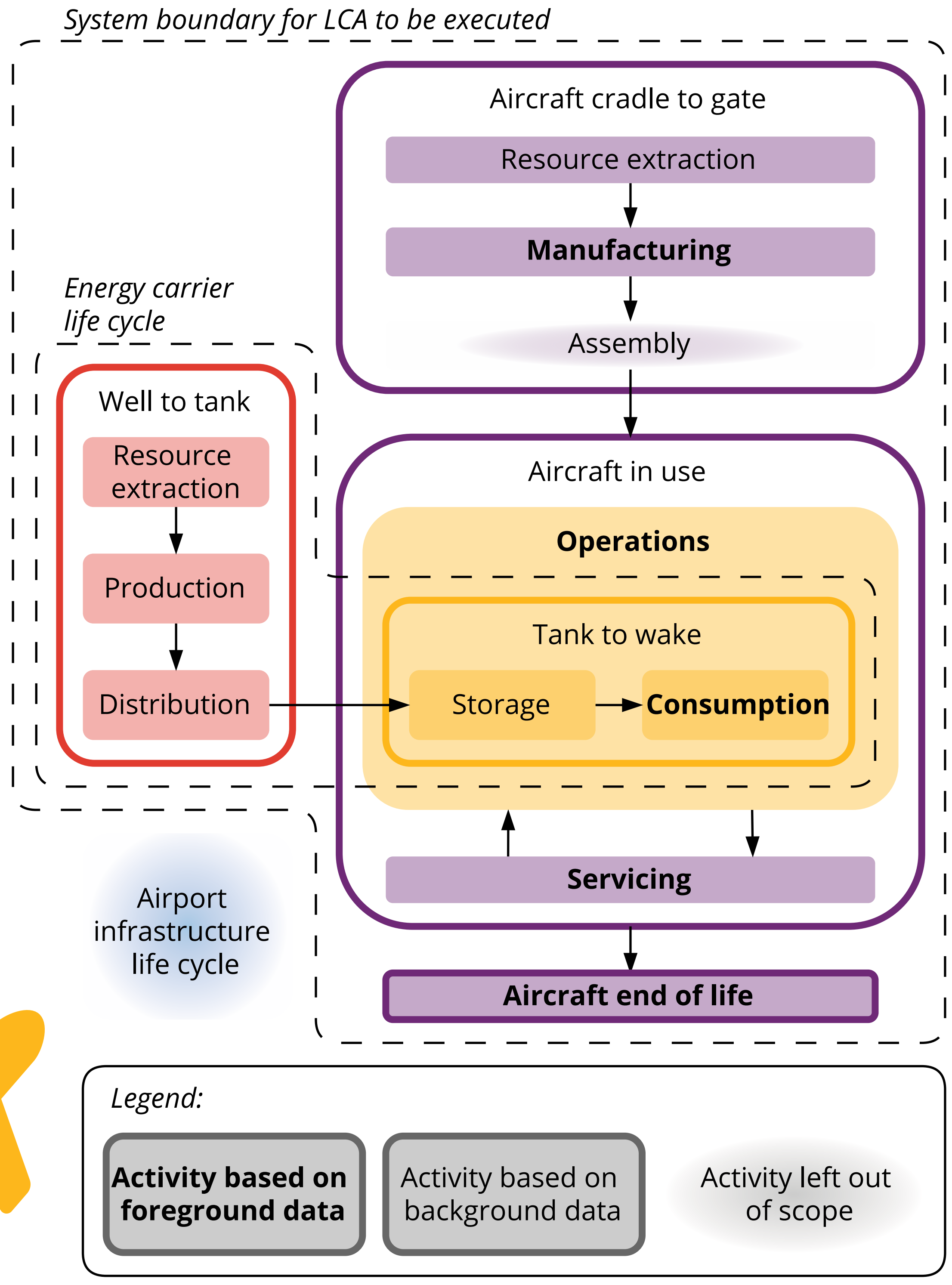


Research question

What is the trade-off in impacts between circularity strategies for aircraft structures and the resulting mass-induced emissions?

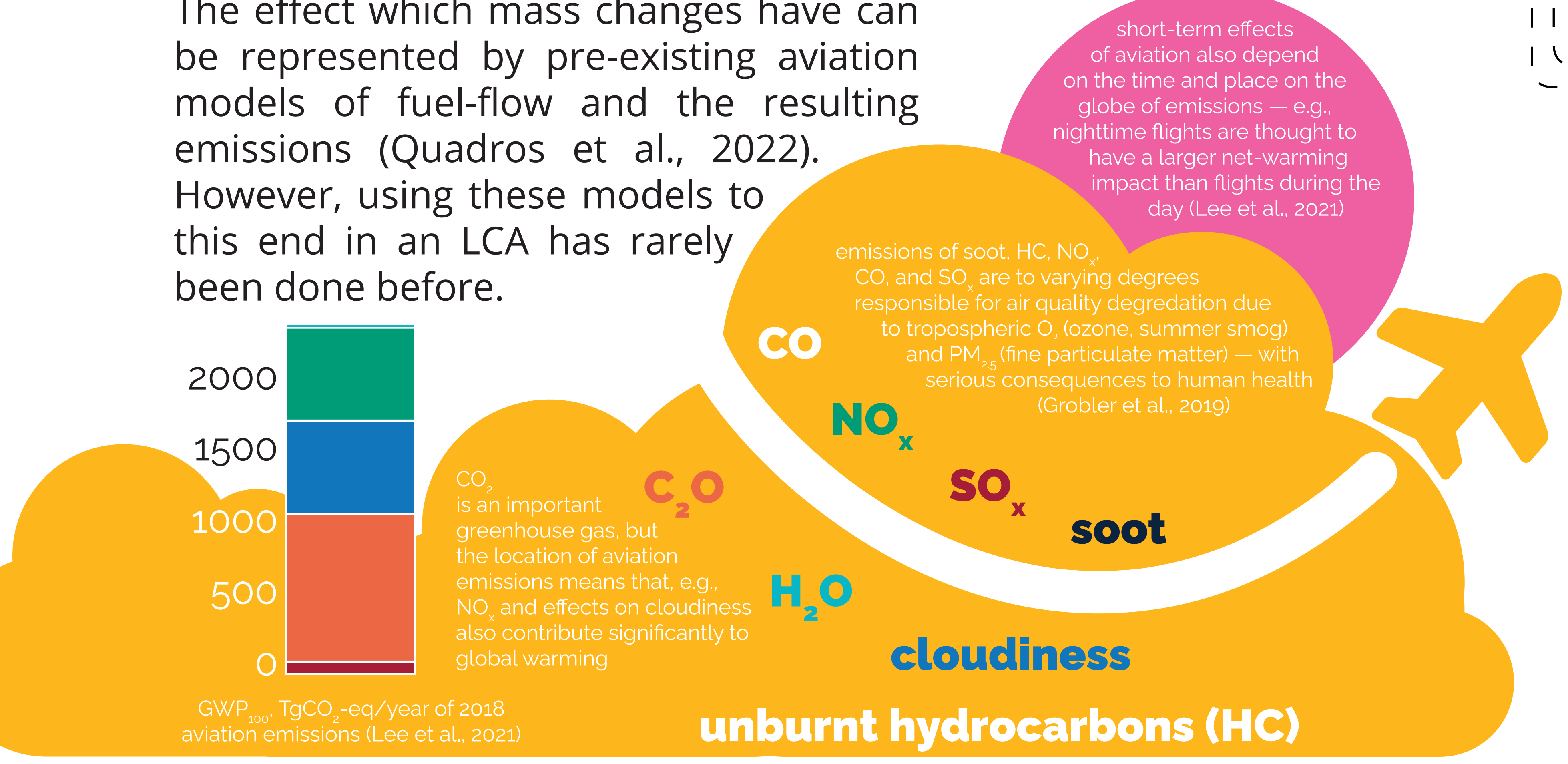
Methodology

A life cycle assessment (LCA) consists of several stages. The schematic on the right illustrates parts of the first two stages: goal & scope definition and the life cycle inventory (LCI). Already here, previous studies have left some gaps. The following stage is life cycle impact assessment (LCIA), where the high altitude of aviation emissions present us with a challenge.



LCI: quantifying emissions

The effect which mass changes have can be represented by pre-existing aviation models of fuel-flow and the resulting emissions (Quadros et al., 2022). However, using these models to this end in an LCA has rarely been done before.



LCIA: non-CO_2 effects

Airports are often close to cities, but cruise altitudes are high above ground. This means conventional LCIA methods become less appropriate. Efforts have been made to determine representative impact factors, but there is still much uncertainty.

Energy carriers

Major transitions in the in-use energy sources for aviation would mean that other aspects of the life cycle will become more important. Such potential future changes will be taken into account through a number of scenarios.

Component case studies

The focus is on opportunities where mass changes between components are minor, but the manufacturing process is well understood, as (1) manufacturing impacts are often simplified to extremes and (2) it is clear that large changes in mass affect in-use energy consumption in a way that cannot be made up for in other life cycle stages.

References

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